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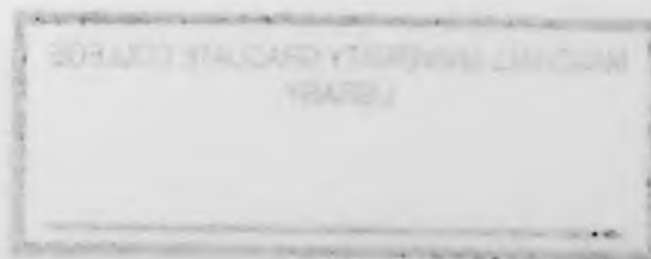
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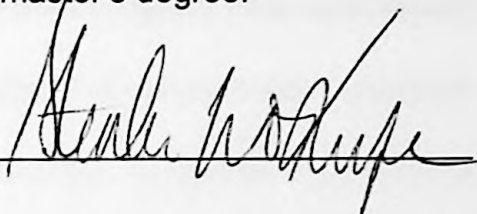
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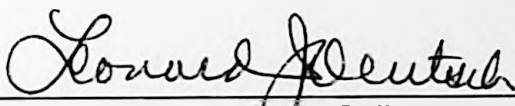


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Abstract

This study examined the Connors' Continuous Performance Test (CPT). The CPT purports to measure levels of vigilance or attention. This test is administered by computer.

Fifty children from a summer school program were individually administered the CPT. A univariate analysis of variance was completed using previous diagnosis of ADHD, gender, and age. A logistic regression was also completed using gender, age, and total score. No significant difference was found.

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The Conners' Continuous Performance Test

Attention as a Variable

Findings have been consistent with the hypothesis that sustained attention develops during the primary school ages. Development is linked to genetic and environmental factors that may interfere with normal brain development. Disturbances in the normal development of these brain areas may contribute to compromised cognitive function in 1) learning disorders (reading, mathematics, and writing disorders), 2) pervasive developmental disorders (autism and Asperger's disorder), 3) attention deficit hyperactivity disorder (ADHD). In children and adolescents with obsessive-compulsive disorder abnormalities in neuropsychiatric, neuropsychological, and neuroanatomical have also been found (DeCaria, Aronowitz, Twersky-Kengmana, & Hollander, 1999).

Attention is a multi dimensional concept that includes alertness and the ability to be selective or focused, to search, and to inhibit distractibility and impulsivity (Barkley, 1988). The introduction of the term "attention deficit disorder" (ADD) to replace "hyperactivity" was influenced by research suggesting that the cognitive aspects of this disorder, most notably inattentiveness and the inability to inhibit impulsive responding, are at least as important as the more obvious motor activity. ADHD is one of the most common disorders of childhood wherein an individual exhibits significant problems with attention span, impulse control, and motor activity level related to similar-age peers (American Psychiatric Association, 1987). As one of the most common Axis I childhood disorders, it is estimated to occur in as many as 3-7% of school aged children

(American Psychiatric Association, 2000). A multi-method assessment approach is typically recommended for diagnosis and treatment. This multi-method includes a diagnostic interview with the parent, completion of behavioral rating scales by the parent and teacher, direct observations of behavior, and administration of clinical test's planning (Barkley, 1990. & Schaughency & Rothlind, 1991). But dissatisfaction with formulating a diagnosis of ADHD based almost entirely upon clinical judgment or the perception of raters has spawned the development of behavior-based assessment procedures.

These efforts typically involve administration of a continuous performance test (Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956). The CPT can be used in the evaluation of ADHD, AIDS related complex (Saykin, Janssen, Cannon, Moreno, Spehn, O'Connor, Watson, & Allen, 1990), closed head injuries (Risser & Hamsher, 1990), Fragile X syndrome (Hagerman, Murphy, & Wittenberger, 1988), Alzheimer's disease (Gordon, Beeber, & Mettelman, 1987), as well as, monitoring responses to stimulant medications (Barkly, Fisher, Newby, & Breen, 1988; Brown & Sexton, 1988). This shift in emphasis from motor activity to the cognitive aspects of ADHD has been accompanied by attempts to assess the cognitive aspects of ADHD directly and has led to the popularity of Continuous Performance Tests (CPT) as aids to diagnosing ADHD (Trommer, Hoeppe, Lorber, & Armstrong, 1988). The computerized CPT is one of the most widely used measures of sustained attention. This may be due, in part, to the fact that children often find working with computers fun and enjoyable (Larsen & Hammill, 1976). CPT are intuitively appealing as diagnostic measures in ADHD

because they require sustained attention over time and are sensitive to even momentary lapses. Yet they are historically nonspecific, and were originally introduced in an effort to differentiate normal from “brain-damaged” subjects without regard to locus, extent, or type of brain injury (Trommer, Hoepfner, Lorber, & Armstrong, 1988).

Differential Diagnosis

Symptoms of ADHD can also overlap with other psychiatric disorders such as Oppositional Defiant Disorder, Conduct Disorder, Depression, Anxiety, and Learning Disabilities. The CPT was unrelated to academic functioning, but commission errors correlated with behavioral measures (Lassiter, D’Amato, Raggio, Whitten, & Bardos, 1994). The commission errors on the CPT were related to oppositional behavior and the Conners’ hyperactivity index, providing further evidence for the diagnostic utility of the CPT. A group of children diagnosed with ADHD and ADHD with Conduct Disorder (CD) missed significantly more target stimuli on the CPT and performed significantly poorer on measures of academic achievement than a group diagnosed purely as CD. However, learning problems did not account for poor performance on the CPT. ADHD may be a cognitively based disorder, whereas CD children are characterized by behavioral symptoms with fewer cognitive and learning deficits (O’Brien, Halperin, Newcorn, Sharma, & et al., 1992). Patients with Major Depression made a disproportionately larger number of omission errors (Hart, Wade, Calabrese, and Colenda, 1998). Findings in patients with Major Depression is consistent with a failure of effort-demanding cognitive processes. CPT scores

of patients with Major Depression with psychosis and schizophrenia were significantly worse than those of patients with major depression without psychosis and normal volunteers (Epstein, Goldberg, Conners, & March, 1997). Attention deficits in Learning Disorder children are considered to reflect a lack of specific learning strategies (Torgesen, 1982), memory deficits (Eliason, 1984), an inability to narrow the focus of attention (Richards, Samuals, Tunure, & Ysseldyke, 1990), or poor allocation of processing resources (Swanson, 1983). The CPT has been increasingly utilized in the assessment of LD as well as ADHD children (Aylward, Verhulst, & Bell, 1990). Attention deficits themselves sometimes have been described as learning disabilities. Attention deficit problems and LD frequently co-occur (Holborow & Beery, 1986; Krupski, 1986; Lambert & Sandoval, 1980), therefore it is important to discern how the two disorders, individually or in combination, may affect performance on frequently used computerized CPT's. For example, an LD characterized primarily by processing problems may affect CPT task performance and, thus, mimic ADHD (Aylward, Verhulst, & Bell, 1990).

Measures of Attention

There are many measures of attention. Rating scales are a standardized format to record behavioral problems and competencies of children as reported by their parents, teachers, and others who know the child well (Doll, 1998). Parents are typically among the most important sources of data about children's competencies and problems. They are usually the most knowledgeable about their child's behavior across time and situations. Furthermore, parental involvement is

required in the evaluation of most children, and parent's views of their children's behavior are often crucial in determining what will be done about the behavior (Achenbach, 1983). Parents' reports should be obtained in the assessment of children's competencies and problems whenever possible.

In a study of the CBCL and the CPT conducted by Burdette (1999), it was found that using a stepwise multiple regression analysis and the Attention Problems Scale of the CBCL as the dependent variable age alone was a significant predictor of parental report with regard to attention problems in a sample of ADHD children. The Attention Problem scale has been shown to be highly predictive of DSM-IV ADHD in other samples (Biederman, et al., 1993; Chen, Faraone, Biederman, & Tsuang, 1994; Hudziak, et al., 1998).

Through the use of several studies, the serious limitations of a checklist approach to the screening of children, when samples are drawn from more general populations have been found (Garrison & Earls, 1985). It is dangerous to assume even when an instrument is working well in one setting, that it is also as applicable in different arenas (McMahon, 1984). More boys than girls have been found in the highest symptom categories; however, a less pronounced gender difference occurred among adolescents girls and boys (Weintraub, 1999). Additionally, age and sex differences have been found in the subscales (Achenbach & Edelbrock, 1983), and thus it is important to continue to explore and test the validity of the CBCL for different populations, and for different subgroups within those populations (Britton, 1994).

Observation and clinical testing is also important in the diagnosis of attention problems. Correlations between CPT measures and IQ, achievement, and memory/learning scores were significant, but generally weak. The CPT number of correct scores were more strongly related to other cognitive measures than were commission (i.e., responding to incorrect stimuli) scores. The breadth and extent of associations among the CPT measures and the various cognitive/academic tasks suggests that all, to some extent, require attention and inhibition. (Aylward, Gordan, & Verhulst, 1997). In a study to assess the influence of gender and verbal intelligence on attention, results indicated that both had an impact on attention performance. Girls performed better than boys; they made fewer errors on the CPT and obtained higher scores on the digit cancellation task and the Coding subtest of the WISC-R (Pascualvaca, Anthony, Arnold, Rebok, Ahearn, Kellam, and Mirsky, 1997).

Continuous Performance Tests

The CPT was first developed to differentiate brain damaged from normal individuals (Rosvold, Mirsky, Saranson, Bransome, & Beck, 1956). Rosvold et al. (1956) used a particular version to detect attention lapses in subjects with petit mal epilepsy. Some CPT's used are the Gordan Diagnostic System (GDS), the Test of Variable Attention (TOVA), and the Conners' Continuous Performance Test (CPT).

The GDS is an 11.5 x 11.5 x 12 inch microprocessor-based portable electronic device that can assess sustained attention through the administration of tasks that require subjects to sustain attention and inhibit behavioral responding

(Baker, Taylor, & Leyva, 1995). The GDS apparatus is amenable to use with diverse populations because it is portable, requires little motoric coordination, and has a large easy-to-read visual display (Rasile, Burg, Burright, & Donovan, 1995). It can be used to administer 11 psychological tests and 2 types of paradigms: delay tasks and vigilance tasks. The delay task is designed as a more distinct measure of impulsivity or ability to delay responding and was derived through Gordon's (1982) doctoral work. It requires the respondent to press a button after a certain time interval (at least 6 seconds for ages 6-16), which is not revealed in the instructions. The vigilance or sustained attention task is a straight forward CPT that requires respondents to press a button when the target visual (a pair of numbers in the correct order) appears and to refrain from responding to any other stimuli (Gordon, 1982). A third version (distractibility task) of the vigilance task presents pseudo-random distracting digits on either side of the central stimulus digits. This task lasts 9 minutes and has norms for ages 6-16 (Oehler-Stinnett, 1998).

The GDS has demonstrated high test-retest reliability (all correlation coefficients significant at the $p < .001$ level) after less than 45 days and after 1 year. Norms have been established by age and sex although gender accounts for only 2% of the variance. GDS scores did not correlate with IQ scores (Gordan & Mettelman, 1988). Concurrent validity has had mixed results. Low to moderate correlation between some GDS scores and "traditional" measures used to assess attention (freedom from distractibility of the WISC-R)(Grant, Ilai, Nussbaum & Bigler, 1990). Gordan (1984) correlation between the GDS and criterion measures

found only Factor IV (hyperactivity) of the Conners Teacher Rating Scale and variables from the Matching Familiar Figures to be significantly related to variables on the GDS Delay Task. Correlations between the GDS and 2 other criterion measures, the Self-Control Rating Scale and the Child Behavior Checklist-Teacher Report Form, were not significant. Gordan (1992) also reported on concurrent validity of the GDS with an undergraduate population and noted correlation between the GDS and tests of attention and performance (WAIS-R: Digit span, Arithmetic, and Digit Symbols and the Matching Familiar Figures Test) to be weak, ranging from .20 to .50.

The TOVA is an individually administered computerized test developed to assess attention and impulse control in normal and clinical populations. The TOVA was developed to measure attention and impulse control processes in these areas: (a) inattention, or omissions; (b) impulse control, or commissions; (c) response time; and (d) response variability. The age range of the TOVA is 4-80+ years of age. There are two easily discriminated geometric pictures centered on the computer screen. One is a target, and the other is a non-target. The subject is instructed to press the micro-switch as quickly as possible after he/she sees the target stimulus. The subject is instructed to not press the switch when the non-target stimulus appears. The test lasts for 21.6 minutes after a 3 minute practice test is given = 24.6 minutes total.

In the beginning the CPT apparatus consisted of a portable electronic device with a display panel and response button. A series of random single-digit numbers is displayed for a period of 0.2 second each with an interstimulus

interval of 1 second for a duration of 9 minutes. Subjects were instructed to press the button every time they saw a recurrent two-digit sequence. An internal microprocessor scored totals correct responses and total commission errors. The current CPT is individually administered on the computer. The respondent is instructed to press the space bar each time he/she sees any letter except X. The test consists of 6 blocks and 33 sub-blocks each of 20 trials. For each block, the sub-blocks have inter-stimulus intervals (ISI) of 1, 2 or 4 seconds. The order of the ISI varies between blocks. Each letter is displayed for 250 milliseconds. The program takes approximately 14 minutes to finish, and it yields scores for overall index, hits, omissions, commissions, hit reaction time, hit reaction time standard error, variability of standard errors, attentiveness, and risk taking. An overall index score less than 8 indicates no attention problem. Scores between 8 and 11 are considered uncertain and warrant further examination. An overall index score greater than 11 offers the heartiest indication of a possible attention problem (Conners, 1995).

This study was designed to examine the diagnostic effectiveness of the Conners' CPT. The research hypotheses are as follows:

1. Younger children will have more errors than older children on the CPT.
2. Boys will have more errors than girls on the CPT.
3. ADHD diagnosed children will have more errors than non-diagnosed children on the CPT.
4. CPT will predict ADHD diagnosis.

Method

Participants

Fifty subjects were tested for this study. The subjects were children who were participating in a summer school program. Their ages ranged between 6 and 15 years, with a mean age of 9 years. The sample included 44% female and 56% male. Ethnic background of the sample was comprised of 10% African-American, 82% Caucasian, and 8% other ethnicities. A previous diagnosis of ADHD was noted for 26% of the subjects and a non-ADHD diagnosis for 74%. There were 8% of the subject that had another DSM-IV diagnosis.

Apparatus

The CPT is a test of vigilance or attention that is administered on the computer. The respondent is instructed to press the space bar each time he/she sees any letter except X and refrain when the letter X appears. The test consists of 6 blocks and 33 sub-blocks each of 20 trials. For each block, the sub-blocks have inter-stimulus intervals (ISI) of 1, 2 or 4 seconds. The order of the ISI varies between blocks. Each letter is displayed for 250 milliseconds. The program takes approximately 14 minutes to finish, and it yields scores for overall index, hits, omissions, commissions, hit reaction time, hit reaction time standard error, variability of standard errors, attentiveness, and risk taking. An overall index score less than 8 indicates no attention problem. Scores between 8 and 11 are considered uncertain and warrant further examination. An overall index score greater than 11 offers the heartiest indication of a possible attention problem (Conners, 1995).

Conners (1995) acknowledged limited research with the CPT, but adds that existing research is complementary. Barkley (1993) acknowledges its theoretical superiority and recognizes the promising research, but he asserts that more research is needed. Reliability information was not available. Conners (1995) lists several studies attesting to the validity of CPT's in general.

Normative data are furnished by the manufacturer so the total correct and total commission error scores may each be assigned independently to a "normal," "borderline," or "abnormal" range. A score is considered abnormal if it was typical of less than 5% of the normative population, i.e., the fifth percentile or less. Scores in the borderline range are those that fell between the 6th and 25th percentiles (Trommer, Hoepfner, Lorber & Armstrong, 1988).

Despite the recent popularity, the face validity of the CPT, and its ability to discriminate several different groups of disabled children from normal controls, little data exists concerning the constructs measured by the CPT (Lassiter et al., 1994). Campbell, D'Amato, Raggio, & Stephens (1991) argued convincingly that the CPT was more clearly related to academic achievement than to verbal intelligence, perceptual-spatial organization abilities, or student behavior. Sex was associated with the hit rate sensitivity on the degraded CPT only (Lin, Hsiao, and Chen (1999). Overall performance on the CPT was found to be related to age, while reaction time was also significantly related to gender (Seidel & Joschko, 1991). A discriminant function analysis correctly classified 72.4% in the ADHD verses normal control comparison, and 66.2% in the ADHD verses non-ADHD comparison (Matier, Perachio, Newcorn, Sharma, and Halperin, 1995). Fisher,

Newby, and Gordan (1995) suggest that the CPT can identify clinically meaningful differences between children referred for ADHD evaluations. There are some studies (e.g. Matier-Sharma, Perachio, Newcorn, Shharma, & Halperin, 1995; Dunne, Arnold, Benson, Bernet, Bukstein, McClellan & Sloan, 1997) that report that CPT's are not typically useful in diagnosis. While other studies (e.g. Fischer, Newby & Gordon, 1995; Lassiter, D'Amato, Raggio, Whitten, & Bardos, 1994; Ludwikowski & Devalk, 1998) provide further evidence in support of the diagnostic utility of the CPT.

Procedure

The individual subjects were placed in a room free from distractions. Each of the subjects read the instructions followed by a brief reiteration by the administrator. The subjects were then monitored during the practice test to make sure the directions were understood. Next, the actual test was given. First, the subjects' demographic information was entered and a final instruction of: "remember to respond as quickly as you can, but also try to make few mistakes." This was to ensure speed and accuracy were equally emphasized before the test began.

Results

The analysis of data was done using a 2 X 2 univariate analysis of variance. Omission and commission errors were combined for a total score. The total score was used as the dependent variable, while age and gender were the independent variables. The mean of the total score was obtained and the subjects were then separated onto two groups. Those children whose total score fell

below the mean were assigned a classification of 1, while those scores above the mean were assigned a classification of 2. Age was also classified into two groups, younger and older. Finally, gender was separated into two classifications. Gender and age were analyzed both separately and together and no significance was found. This suggests that there is no significant difference in gender or age on the CPT with regard to the diagnosis of ADHD.

Further, the sample was not normally distributed; therefore, the assumptions of regression were violated; consequently a logistic regression was completed. Prior diagnosis was used as the dependent variable and gender and total score as covariates.

Discussion

The results of this study found that the CPT was not a good predictor for diagnosing ADHD. Furthermore, it is a likely conclusion that the intangible constructs that make up ADHD cannot be distinguished by one measure alone. Clinicians who use the CPT to screen for ADHD are advised to include a more thorough evaluation instead of relying solely on this test.

Out of thirteen previously diagnosed ADHD children, the CPT computer generated report correctly diagnosed eleven of them. However, the CPT computer generated report incorrectly diagnosed non-ADHD children as ADHD in 22 cases out of 37 children.

Of interest, in the two cases of ADHD previously diagnosed that the CPT did not pick up, all three indicators did not pick up any characteristics of ADHD: computer algorithm printout, index score, and total score. In four of the 22 false positives, 4 showed all three indicators as ADHD. Although not statistically significant, these items may provide a source for further study. Even though the CPT is not a statistically significant predictor of ADHD, the highest number of hits occurred with the computer algorithm printout.

One limitation of this study was the nature of the sample. There were a disproportionately higher number of participants that were ADHD than in the typical classroom. Therefore, generalizations to other groups should not be made. Another limitation is that there is very little information regarding the validity and reliability of the Conners' CPT. Further research with a larger normal sample size is needed to address these issues.

In conclusion, more research is needed to identify the underlying constructs of inattention and impulsivity that make up ADHD.

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